EXHIBIT 12

Television Engineering Handbook

Featuring HDTV Systems

Revised Edition

K. Blair Benson *Editor and Coauthor*

(Deceased) Formerly: Engineering Consultant; Member, Audio Engineering Society; Senior and Life Member, Institute of Electrical and Electronics Engineers; Fellow and Life Member, Society of Motion Picture and Television Engineers

Revised by **Jerry C. Whitaker**

Technical Writer; Broadcast Engineering and Video Systems Fellow and Member; Society of Broadcast Engineers; Member, Audio Engineering Society; Member, International Television Association; Member, Institute of Electrical and Electronic Engineers; Member, Society of Motion Picture and Television Engineers

McGraw-Hill, Inc.

New York St. Louis San Francisco Auckland Bogotá
Caracas Lisbon London Madrid Mexico Milan
Montreal New Delhi Paris San Juan São Paulo
Singapore Sydney Tokyo Toronto

Library of Congress Cataloging-in-Publication Data

Television engineering handbook/K. Blair Benson, editor in chief.—
Rev. ed. / rev. by Jerry C. Whitaker.
p. cm.
Includes index.
ISBN 0-07-004788-X:
1. Television—Handbooks, manuals, etc. I. Benson, K. Blair.
II. Whitaker, Jerry C.
TK6642.T437 1992
621.388'87—dc20

91-35079
CIP

1 2 3 4 5 6 7 8 9 0 DOC/DOC 9 7 6 5 4 3 2

Scannable ISBN

The sponsoring editor for this book was Daniel A. Gonneau, the editing supervisor was Kimberly A. Goff, and the production supervisor was Suzanne W. Babeuf.

This book was set in Century Schoolbook. It was composed by Progressive Typographers.

Printed and bound by R. R. Donnelley & Sons Company.

video channels is desired from the head end to subscribers. In institutional networks, however, it is desirable to have an equal number of channels in each direction, so upstream transmission is usually from 5 to 150 MHz and downstream transmission utilizes the frequencies from 200 MHz up.

As hybrid amplifiers, the main element in CATV amplifiers, improve, the upper-frequency limit of CATV systems is being increased. At present, 500-MHz amplifiers have been developed, and it is likely that the upper-frequency maximum will be even higher in the near future. Other elements of the CATV network, such as passive line splitters, cable, and converters, are already available with capabilities of 500 MHz and higher.

With a single cable, a maximum of 54 video channels can be carried in the downstream direction on a 400-MHz system (36 on a 300-MHz system). However, FCC Rules and Regulations which prohibit CATV systems from using frequencies in the aircraft navigation and communications bands often make several channels unusable. As a result, the actual number of channels carried on most 400-MHz systems is approximately 50 (32 on a 300-MHz system). Many systems are now being built with a dual-cable subscriber network. With this approach, the channel capacity is doubled.

In addition to the video channel capacity of CATV systems, there is space for the FM radio band (88 to 108 MHz), various control signals, and digital data transmission. In the upstream direction, a theoretical capacity for five video channels exists. However, few cable systems utilize more than one video channel in the upstream direction. Most uses for the upstream spectrum are digital.

The channels carried between 54 and 88 MHz are referred to as *low band* (channels 2 to 6), and those between 120 and 174 MHz are called *Midband* (channels A to I or 14 to 22). The frequencies from 174 to 216 MHz are called *high band* (channels 7 to 13), and those above 216 MHz are referred to as *superband, hyperband,* and *ultraband,* (channels J and up or 23 and up). See Table 13-2 for a typical CATV channel allocation and identification.

Institutional networks generally allocate 20 or 25 channels in the downstream direction and 15 to 20 channels in the upstream direction. Since most institutional networks are carrying only experimental services, the final channel configurations have not yet evolved. It is likely, however, that a good portion of the spectrum on institutional networks will be dedicated to digital transmission.

9.3 HEAD END

The *head end* of a CATV system is the origination point for all signals carried on the system. Signals are received off the air, from satellites, and from terrestrial microwave systems. In addition, many signals are originated at the head end. Signals are processed and then combined for transmission over the cable system. In bidirectional systems the head end also serves as the collection point for all signals originating within the subscriber and institutional networks.

The major elements of the head end are the antenna system, signal-processing equipment, pilot carrier generators, combining networks, and equipment for bidirectional and interactive services. See Fig. 9-2 for a typical CATV head end.

A CATV antenna system includes a tower and antennas for reception of local and distant stations. For distant signals, tall towers with high-gain directional receiving antennas are utilized to provide sufficient gain to pick up the desired signal and provide discrimination against unwanted adjacent channel, co-channel, or reflected signals. Antennas are located in an area of low ambient electrical noise where it is possible to receive the desired television channels with a minimum of interference and at a sufficient level to obtain a high-quality signal. For weak signals, low-noise preamplifiers are used near the pickup antennas. Strong adjacent channels are attenuated through the use of bandpass and bandstop filters.

Satellite earth receiving stations, or television receive only (TVRO) stations, are used by most CATV systems. Earth stations are located to minimize interference from terres-

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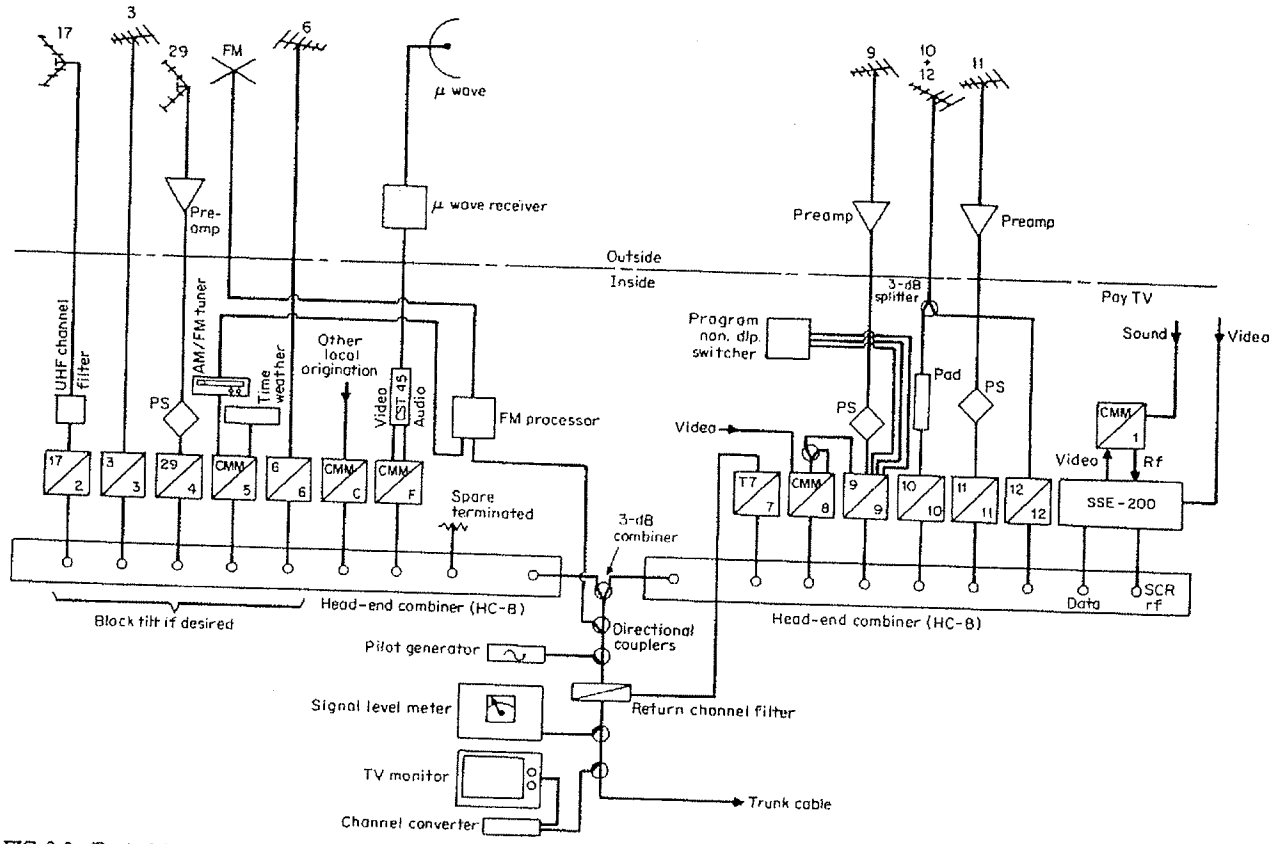

FIG. 9-2 Typical CATV head end. [*D. G. Fink and D. Christiansen (eds.), Electronics Engineers' Handbook, 2d ed., McGraw-Hill, New York, 1982.*]

trial microwave transmissions, which share the same 4-GHz spectrum, and to allow an unobstructed line-of-sight path to the desired satellites. Earth stations consist of a receiving antenna [usually a parabolic reflector 13 to 23 ft (4 to 7 m) in diameter], low-noise preamplifiers at the focal point, and a waveguide to transmit the signals to receivers.

Signal processing is performed at the head end for the following reasons:

1. To regulate the signal-to-noise ratio at the highest practical value
2. To control the output level of the signal to a close tolerance automatically
3. To reduce the aural carrier level of television signals to avoid interference with adjacent cable channels
4. To suppress undesired out-of-band signals

Processing is used also to convert the received signals to a different cable channel and to convert UHF signals to VHF cable channels. Processing of off-air television signals is done either with a heterodyne processor or a demodulator-modulator pair. Signals received by satellite are processed by a receiver and then placed on an appropriate vacant cable channel by a modulator. Similarly, locally originated signals are converted to a cable channel with a modulator.

Pilot-carrier generators provide precise reference levels for the proper operation of the trunk system. Generally, two reference pilots are provided, one near each end of the cable spectrum. Combining networks are used to group all signals from individual processors and modulators into a single output for connection to the CATV network.

In bidirectional systems, a computer system is located at the head end. The configuration of the computer varies with the type of service to be offered and can range from a small microprocessor and single display terminal to multiprocessor minicomputers with many peripherals. Such computers control the flow of data to and from terminals located within the CATV network. See Fig. 9-3 for a typical bidirectional head end.

Interactive services require one or more data receivers located at the head end. Polling of home terminals is controlled by data transmitters. Polling and data collection are controlled by the computer system. Where CATV networks are used for point-to-point data transmission, *modems* are supplied at each end location, and *RF-turnaround converters* are used to redirect incoming upstream signals back downstream.

Modern CATV systems utilize computerized switching systems to program one or more video channels from multiple-program sources. In addition, computer-controlled alphanumeric character generators are used to program automated information channels.

Institutional networks in CATV systems require switching, processing, and turnaround equipment at the head end. Video, data, and audio signals, originating within the network, must be routed back out over either the institutional or subscriber network. One method of accomplishing this is to demodulate the signals to baseband, route them through a switching network, and then remodulate them onto the desired network using demodulators and modulators. Another method is to convert the signals to a common intermediate frequency, route them through a radio-frequency switching network, and then up-convert them to the desired frequency. This method utilizes heterodyne processors.

In larger systems, different areas of the network may be tied together with a central head end utilizing supertrunks or multichannel microwave. In this method, called the *hub system*, supertrunks are high-quality trunks often utilizing FM transmission of video signals or feed-forward amplifier techniques to reduce distortion. Multichannel microwave transmission may use either amplitude or frequency modulation.

Supertrunks or multichannel microwave systems are also used where the pickup point for distant over-the-air stations is located away from the central head end of the system, and to interconnect CATV systems owned by different operators in the same geographic area.